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ORGANIZATIONS FOR PROJECT MANAGEMENT IN THE DEFENSE INDUSTRY

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Monterey, California

THESIS

ORGANIZATIONS FOR PROJECT MANAGEMENT

IN THE

DEFENSE INDUSTRY

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Organizations for Project Management in the Defense Industry

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

In recent years, companies involved in contracting with the Department of Defense have organized project offices to manage the development and production of defense systems. The organizational structures and authority relations of these offices are unlike those common to other activities. This study sought to identify and explain the relationships that exist between structural and authority variables of project management systems. Data was collected by structured survey questionnaires directed to project managers and related functional managers. A correlational analysis was employed to measure the strength of relationships between attitudes and structural variables.

Although the dollar value of a project proved to be an important structural variable, the most reliable predictor of a manager's perceived authority was the number of layers between him and the top level of corporate management.

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I. INTRODUCTION

The growing complexity of corporate structures requires a re-examination of the organizational forms that can be effectively managed. In the defense industry this need has been particularly acute because of the demands for the production of costly advanced weapon systems with short development lead times. As a result, most companies contracting with the Department of Defense (DOD) have adopted some form of project or program management.[1]

The approach to project management varies greatly within the defense industry, just as it does within the military services. Not only are different organizational forms used, but there is also a wide range of authority delegated to the project managers.

The purpose of this thesis is to identify and explain the relationships that exist between the structural characteristics of an organization and the project manager's perception of his own authority. Structural variables include company size, complexity and dollar value of its products, organizational form employed, and the number of levels which exist between the project manager and top corporate management. Areas of project authority include direct control over people,

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[1] In this paper, as in many companies, these terms are used interchangeably.

selection of office staff and subcontractors, regulation of program changes, contracting, and budget preparation. These and other variables are measured against one another to determine whether certain types of projects tend to be managed in specific ways. Data obtained from questionnaires and interviews is analyzed statistically in order to determine the strength of specific relationships.

The actual analysis is preceded by a discussion of the evolution of project management and a description of the organizational forms currently in use.

II. PROJECT MANAGEMENT

A. BACKGROUND

The concept of project management is not without historical precedent. In all likelihood it was practiced by the builders of the pyramids who, as an organization, existed for a specific purpose, involved people of various specialties, and then dissolved when the job was done.

Since the Industrial Revolution, project management has been used for complex, one-time projects such as building bridges or tunnels, or for designing and constructing new plants.

Most work performed by production and construction firms, however, is of simple enough nature to be accomplished within a conventional or "functional" structure. Functional organizations consist of departmentalizing manpower according to talent, skill, or specialty. This is typically exemplified by the engineering, manufacturing or marketing departments found in major companies.

Prior to World War II a weapon system procured by the Department of Defense (DOD) could typically be designed by a firm's engineering department, produced by its manufacturing department, and sold by its marketing department. World War II, the Korean conflict, and Vietnam have had a marked impact upon this traditional approach to developing and producing weapons. First, the past three decades have been characterized

by a technology that expanded faster than in all of the preceding history. Due in large part to efforts of defense and space-oriented industries, the state of the art in airframes, electronics, propulsion and guidance systems has been pushed rapidly through one threshold after another. Second, the demands of armed forces engaged in combat operations have created exceptionally short but firm lead times for new weapon systems. So rapid has weapons development become that the equipment occasionally is obsolete before it is ever used. To keep abreast of technology, DOD and its industrial contractors have assigned managers to specific projects with responsibility for all phases of procurement. Generally included in such a project manager's realm are the functions of design, development, production, delivery and certain aspects of system support. To complement this responsibility the manager is usually empowered to cross functional organization lines to obtain the personnel and other resources he needs to get the job done. A project manager typically is responsible for creating an end-product that must meet stringent technical specifications, with tight budget and schedule constraints. These three major dimensions (cost, schedule and technical performance) form the basis for constant conflicts, resolved largely by trade-off decisions made by the project manager (PM). Further conflict peculiar to project management arises from the competition for resources between the PM and other project and functional managers.

The first modern use of project management in weapon system development was the Manhattan Project, established in 1942 to build the atomic bomb. In 1957 the Special Projects Office was established by the Navy to manage the development of the Polaris Fleet Ballistic Missile Weapon System. Johnson, Kast and Rosenzweig illustrate the wide scope of this organizational mandate:

"1. Developing, testing, and producing the Polaris missile

2. Coordinating construction of nuclear-powered submarines and development of advanced communication systems

3. Developing, testing, and producing, launching and handling, fire control, and navigation systems

4. Training Fleet Ballistic Missile personnel, including crews and the nuclear assembly, storage, and issue facilities

5. Conducting tests to insure that fully operational weapon systems are turned over to the fleet on or before the required time

6. Constructing and equipping the over-all system production facilities, including buildings, production, test and inspection tooling, and a maintenance facility

7. Management of fiscal and other resource matters for the entire Fleet Ballistic Missile Program"2

Although the Manhattan and Polaris projects were far more complicated and extensive than most DOD procurements, they represent the formalization of project management techniques in the military-industrial complex. The project management concept, old as it is, has not been the subject of great

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2 Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig, The Theory and Management of Systems, p. 154, McGraw-Hill, 1967, citing Polaris Management, Department of the Navy, Special Projects Office, Fleet Ballistic Missile Program, 1961, p. 2.

concern by organizational or management theorists. Its success in coping with advanced technology and critical lead times in two highly important projects led to increased interest by all services and their contractors. The advent of the National Aeronautics and Space Administration (NASA) in 1958 also contributed to the trend toward project organizations. As project managers were designated within DOD and NASA, those prime contractors associated with development of major systems responded by naming a representative to manage the project within the company. These managers and their government counterparts represent the principal interface between the user and producer of major systems.

Today DOD has approximately 130 designated major projects, nearly all with a corresponding project manager in industry. Subcontractors at all levels have also become highly project oriented, many assigning an individual to manage all aspects of a particular contract (or group of related contracts). This trend toward great emphasis on projects in government and industry has prompted a flood of literature in the past nine years. To students of management and organization, however, it appears that the practice remains considerably ahead of the theory. Succeeding sections of this paper represent an attempt to add a new perspective to this subject.

B. ORGANIZATIONAL FORMS[3]

As mentioned in the preceding section, weapon systems were once produced almost entirely by conventional authority relations among a company's functional departments. This organizational form still finds limited use for project work, particularly on small contracts involving comparatively simple systems or equipments. Referred to as the functional project form, it is typically headed by a project engineer, accountable to a department head, and limited to those formal authority relationships existing with his direct subordinates. Functional departmentation usually is according to specialized division of labor or by product. Typical functional departments would include engineering, manufacturing and marketing. A commonplace form of functional project organization for engineering is illustrated in Figure 1.

A second type of project organization is the vertical project office. This form is also called a monolithic or pure project organization. The vertical project team is often found in unusually important (high dollar value), lengthy, or highly sensitive projects. It is generally headed by a high-level manager exercising direct line authority over all

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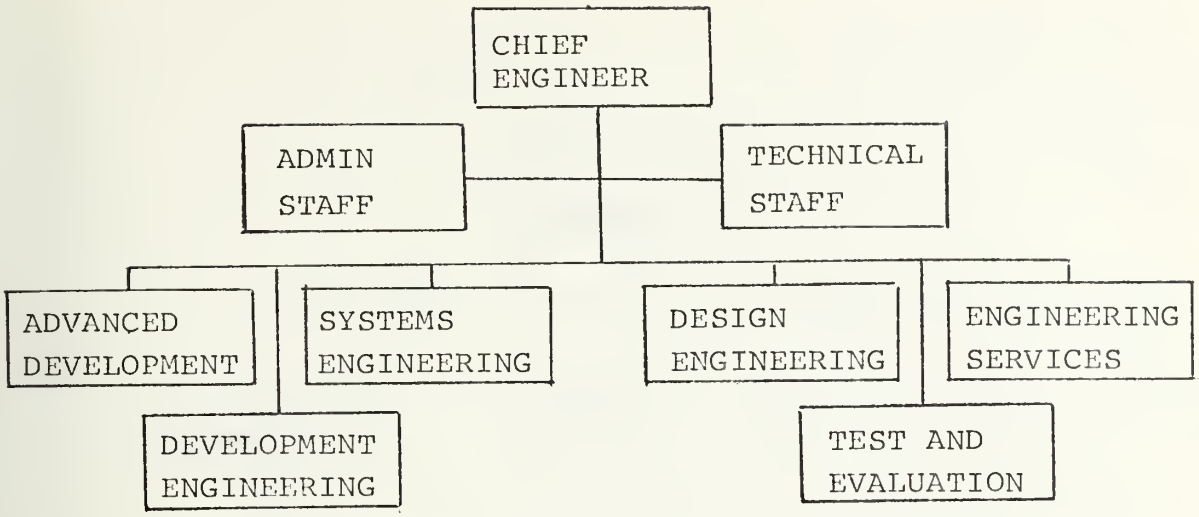
[3] Much of this section, including illustrations, is based on unpublished lecture notes, "Engineering Organizational Forms," by Melvin B. Kline, and on Systems Analysis and Project Management, by David I. Cleland and William R. King (New York, 1968), pp. 160-193.

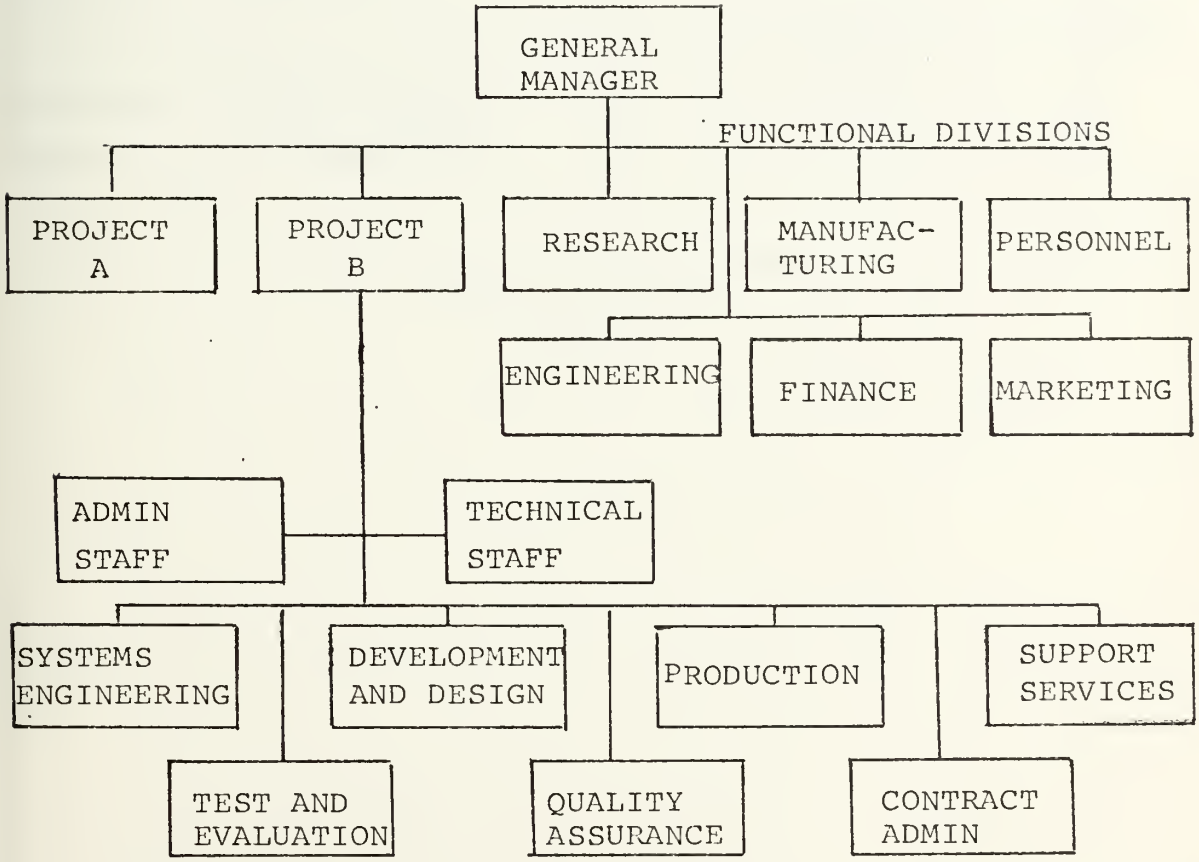
persons involved in the development of a system. Contracting, engineering, and production personnel are among those responsible directly to him; they are usually assigned duties exclusively related to the project. The project manager makes all decisions involving workload, promotions, and salary. Figure 2 is a simplified example of this type of organization.

A common form of project organization today is the matrix organization, illustrated in Figure 3. A matrix form combines features of both the functional and vertical organizational forms. It is characterized by a relatively small project office staff, responsible for portions of the project that require the assistance of technical personnel outside the sphere of the project manager's formal authority. This arrangement is characteristic of project management, since the manager is granted authority to cross traditional functional lines of authority in all matters related to his project.



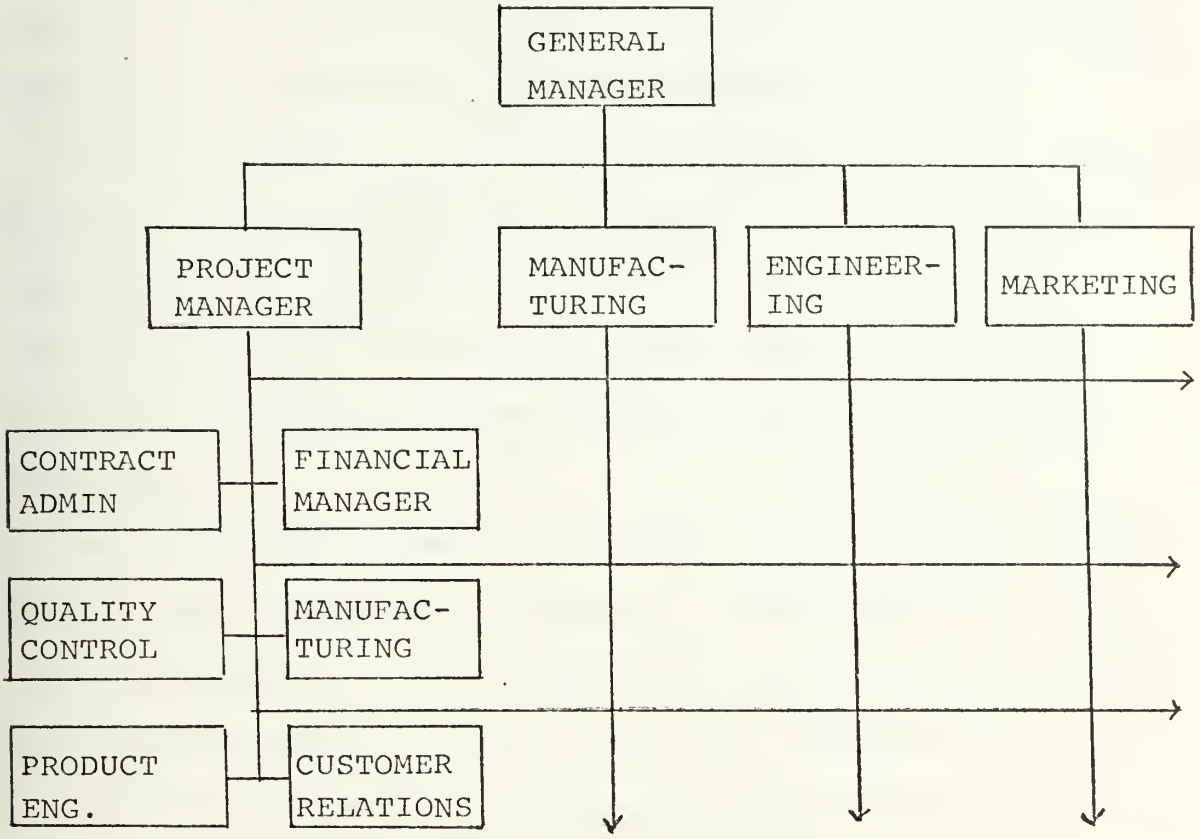
FUNCTIONAL ORGANIZATION

Figure 1



VERTICAL ORGANIZATION

Figure 2



MATRIX ORGANIZATION

Figure 3

There are numerous variations of the matrix organization form. Due in part to its widespread use in the defense industry, the matrix form has become synonymous with the broader term, project management, to many managers.

Types of matrix organizations may be specified by the way in which they use functional personnel. In some instances, such people are "acquired" by the project office. That is, they become fully dedicated to a particular project to the exclusion of doing any other work in their own functional department.

More commonly, however, the functional people are subject only to the "influence" of project offices, carrying out tasks that may be assigned them within the physical environs and line management of their functional organization.

Another distinguishing characteristic of the matrix management form is the degree to which the parent organization relies on projects for development of its products. While a company (or one of its divisions) may depend entirely on government contracts, another may additionally produce a number of more conventional products for a commercial market. This can be the source of considerable differences in the degree of strain placed on functional organizations by competition for their attention among several projects.

C. ADVANTAGES AND DISADVANTAGES[4]

That only the functional form was necessary for so long indicates that there are many circumstances requiring no other organizational form. Galbraith, for example, states that the need for technical expertise is most satisfactorily fulfilled by managing technical personnel with administrators most familiar with the various specialties.[5] This can be accomplished in one functional organization easier than by requiring a single project manager to attempt to be expert in many areas. Supervision by one of their own kind leads to higher morale among technical personnel by providing a clear definition of promotion lines. Communication problems are minimized, decisions are made promptly, and an effective informal organization normally exists.

Balancing these points are the shortcomings that arise from a lack of identity with any given project. Engineers, for example, seldom visualize the project beyond the scope of the performance characteristics of an individual component or subsystem. Thus, overall project requirements and customer needs often take a back seat to problems of a purely technical nature in functional organizations.

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[4] Ibid.

[5] Galbraith, Jay R., "Matrix Organization Designs," Business Horizons, February, 1971, p. 38.

For greater project efficiency and effectiveness, many project managers would prefer the vertical form of organization. With control over hiring, firing, salary reviews and personnel placement, the manager of vertical projects meets with quicker response time and higher project motivation than in other forms. This concentration of authority facilitates accounting and the making of binding decisions.

Advocates of this vertical form are countered by managers who would rather have a few people overworked than a lot of them milling around without work. Skills and facilities are often duplicated at a great expense to the company. In a large organization involved in a complex project, it is practically impossible to make effective use of everyone simultaneously. Design personnel, for example, usually have less to do once test and evaluation has begun than during the preceding stages of development. Furthermore, technical performance may suffer from lack of sufficient supervision.

The matrix organizational form combines many of the advantages of the other two types without as many of the disadvantages. A leading advantage is the matrix form's flexibility. Matrix organizations can be easily adapted to a particular project. Moreover, they can also be adapted to a specific phase of its life cycle. Fluctuations can be made in the number of people involved in the project without disturbing functional routines. Technical excellence is maintained through effective functional supervision, project motivation is high, and managers are often developed from

technical ranks. Conflict between the project and functional managers becomes the basis of an effective system of checks and balances.

The chief objection to the matrix form is not the inevitable conflict that arises between project offices and functional departments. Rather is is the intense competition among several project managers for the required functional assistance. Whether the matrix structure is of the "influence" or "acquiring" form, there is often intense competition for the services of these personnel. Furthermore, an engineer may be "loaned" to a project office for as long as several years. During this time he is apt to become parochial, and thus removed from the routine of his "native" functional organization. This is particularly true of personnel involved in a particularly sensitive or unique project. As his part in a project nears completion, a sense of insecurity may develop in an engineer. Returning to his organization he may find no requirement for his skills, a serious problem in an industry familiar with massive job reductions.

Conflicts also are likely to arise between the needs and desires of a project manager and those of his functional counterpart. The chief engineer is used as an example since he and the project managers often have the same reporting senior. Having jurisdiction for technical personnel involved in many projects and other work, the chief engineer's objectives are not always bounded by time constraints and he is thus likely to be driven by far-reaching goals of the entire

company. The project manager, on the other hand, quite often becomes nearsighted, concerned only with the immediate goals of his project. Stewart suggests that "short-term conflicts can often be resolved in favor of the project manager and long-term conflicts in favor of the functional managers. This compromise helps to reduce friction, to get the job accomplished, and to prepare for the eventual phasing out of the project."[6] When the project manager reports to the chief engineer, however, some sacrifice may be required by the latter to ensure equitable resolution of the conflicts.

D. THE PROJECT MANAGER

The individual assigned to manage a complex technical project is quickly entrenched in a web of unique reporting relationships and communication channels. Traditional management principles of authority and responsibility are almost routinely inapplicable. More important is the individual's mastery of "influence management," his ability to direct and control people outside his own organization. A more inclusive look at the characteristics of the form is given by Cleland's differentiation of a project manager from a functional manager:[7]

1. Accomplishment of his project requires participation by organizations outside his direct control.

2. His authority in functional areas conflicts with that of the functional managers.

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[6] Stewart, John M., "Making Project Management Work," Business Horizons, Fall, 1965, pp. 63-64.

[7] Cleland, David I., "Why Project Management?" Business Horizons, Winter, 1964, p. 82.

3. He determines the when and what of project activities; the functional manager determines the how.

4. His task is finite. His personnel will later be assigned to other activities.

5. He oversees a high percentage of professionals.

6. His role is that of a unifying and integrating agent. Directing is accomplished through the functional managers who support him.

7. He does not normally possess line authority over the organization creating the product.

To cope with this unconventional environment the project manager will find relatively little written guidance in the vital techniques of persuasion, salesmanship and in-fighting. Gemmill and Wilemon have described the power spectrum used in project management by defining five basic sources of influence:

"1. Formal Authority--the ability to induce or influence others to meet his requests because they perceive him as being officially empowered to issue orders.

2. Reward Power--the ability to induce others to meet his requests because they value the rewards they believe he is capable of administering.

3. Punishment Power--the ability to induce others to meet his requests because they wish to avoid punishments they believe he is capable of administering.

4. Expert Power--the ability to induce others to meet his requests because of their respect for his technical or managerial expertise.

5. Referent Power--the ability to induce others to meet his requests because of their feelings of identification with him, with the project, or with the position of project manager."[8]

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[8] Gemmill, Gary, and David L. Wilemon, "The Power Spectrum in Project Management," Sloan Management Review, Fall, 1970, p. 16.

Use of one or more of these sources aids a manager in ensuring the competent completion of his project. The effectiveness with which he uses these tools is often a detriment in the degree of success his project enjoys.

III. ANALYSIS

A. METHODS

1. Instrumentation

Data for this study was collected by means of a questionnaire mailed to 96 project managers. Divided into five sections, the questionnaire sought the following information:

a. Education and experience of a project manager
b. Characteristics of a project's end-item
c. Structural characteristics of a project office
d. A project manager's perceived authority
e. Characteristic problem areas

A copy of the questionnaire is in Appendix A.

Follow-up interviews were made with 12 of the project managers. Moreover, ten others, representing functional organizations and corporate management, were interviewed. Gathered from the interviews were organization charts, information about company project management policy, employment and sales data, and explanations of problem areas. Initial contact with the firms was made by telephoning a project or functional manager or a firm's Naval Plant Representative Office (NAVPRO).

The specific variables analyzed were:

a. Annual sales--an estimate obtained from interviews and annual reports, of the 1971 sales of the company (or a specific division), measured in dollars.

b. Employed--an estimate, also obtained from interviews, of the number of people employed by a company (or division).

c. Complexity--the complexity of the project's primary end-product, ranked by the author upon the return of all questionnaires.

d. Layering--the number of levels existing between the project manager and top corporate management (president, for example), obtained from interviews and organization charts.

e. Dollar value--as answered on the questionnaire, the approximate dollar value of contracts pertaining to the project.

f. Involvement--the degree of government involvement in the project, as answered on the questionnaire.

g. Organization form--the project manager's choice on the questionnaire of functional, matrix, or pure project form. In the analysis, functional forms were ranked as the least vertical, pure project the most.

Variables h - n were obtained entirely from the questionnaire in answer to questions written by the author.

h. Staff selection--the amount of his authority, as perceived by the project manager, in selecting his office staff.

i. Contracting--the amount of his authority, as perceived by the project manager, in negotiating contracts.

j. Subcontracting--the perceived authority of the project manager in selection of subcontractors.

k. Budget--the amount of responsibility, perceived by the project manager, in his preparation of the project's budget.

l. Technical change--the amount of control exerted by the project manager over technical changes.

m. Schedule change--the amount of control exerted by the project manager over schedule changes.

n. Cost change--the amount of control exerted by the project manager over cost changes.

2. Sample

Twelve firms involved in contracting with DOD were selected for sampling. These organizations ranged from entire corporations to companies, groups, and divisions within a corporation which could be treated as profit centers. The companies, the specific divisions sampled, and their locations are listed in Appendix B. These companies were all ranked among the 40 leading DOD contractors for Fiscal Year 1972.[9]

The number of persons sampled in each firm ranged from two to 13. While questionnaires were directed primarily at project managers, some of them were also answered by representatives of functional organizations. Additionally, interviews were conducted with group and corporate executives, as well as the project managers and their deputies. Eighty-seven questionnaires were used in the statistical analysis.

3. Statistical Methods

The analysis consisted primarily of establishing the strength of certain relationships, based on data obtained from completed questionnaires. Using the Statistical Package for the Social Sciences (SPSS),[10] cross tabulations were

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[9] "Top 100 Defense Department Contractors for Fiscal 1972," Aviation Week and Space Technology, December 11, 1972, pp. 58-61.

[10] Nie, Norman H., Dale H. Bent, and C. Hadlai Hull, Statistical Package for the Social Sciences (New York, 1970).

compiled between structural variables and managers' perceptions of their own authority. The strength of these relationships was measured by the Kendall rank-order correlation coefficient (tau). Kendall's tau is a measure of "standardized coefficients based on the amount of agreement between two sets of ordinal rankings."[11] It was selected over the other prominent nonparametric coefficient, Spearman's r_s, since tau seems to be "somewhat more meaningful when the data contains a large number of tied ranks."[12] Both require only that the variables being compared are measured on at least an ordinal scale.

Kendall's tau is defined by the mathematical expression:[13]

$$\text{tau} = \frac{S}{(1/2\ N(N-1)-T_X)^{1/2}(1/2\ N(N-1)-T_y)^{1/2}}$$

where S is a statistic which measures the "disarray" of the two variables, T_X and T_y are corrections for tied ranks, and N is the sample size.

The computed coefficients were then tested for significance by comparing tau to a normal distribution with a standard deviation equal to

$$\left(\frac{4N+10}{9N(N-1)}\right)^{1/2}$$

The significance level (p) represents the probability of

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11 Ibid., p. 154.

12 Ibid., p. 153.

13 For a discussion of the derivation of this expression and its significance test, see Nonparametric Statistics for the Behavioral Sciences, by Sidney Siegel (New York, 1956), pp. 213-222.

accepting the hypothesis that two variables in a population are unrelated. The smaller the value of p, the stronger is the relationship between the variables tested.

B. FINDINGS

1. Data

Results of the analysis were arranged in a correlation matrix, contained in Appendix C. The figures listed represent the significance level (p), and a minus sign represents inverse correlations. Statistically significant ($p \leq .05$) figures are underlined.

Appendix D illustrates the sample size (N) and Kendall's coefficient (tau) required for selected significance levels.

2. Structural Variables

As mentioned in the introduction, structural variables include size of the company (measured in annual sales and number of employees), dollar value of the project, product complexity, layering and organizational form.

a. The dollar value of a project correlated strongly ($p = .01$) with the annual sales of a company, the number of employees, the complexity of the end-product, government involvement, and inversely with layering. Thus, the higher the dollar value of a project, the more likely that it was found in a large company and was managed by a high level individual.

b. Complex, high dollar value projects tended to be organized more vertically than lower value ones.

Organizational form's relationships with annual sales and number of employees were also significant.

c. Layering was significantly linked with more items than any other structural variable. It was inversely related to every authority variable analyzed, meaning that the fewer levels existing between the project manager and the company president, the higher his perceived authority in contracting, staff and subcontractor selection, budget preparation, and change control.

d. Government involvement was found to the greatest degree in high dollar value, complex products.

3. Authority Variables

These variables include contracting, subcontracting, staff selection, budget preparation, and control over technical, cost and schedule changes.

a. Managers who perceived themselves as having broad authority in one area generally had similar perceptic s of their authority in all other areas. Consistently strong ($p = .001$ in all cases) were the relationships among budget preparation and the three areas of change control.

b. Staff selection led the authority variables in significant links with other items. It was not only related to all other authority variables, but also to such structural variables as product complexity, dollar value, and organizational form. Managers of high dollar value, complex projects thus reported greater staff selection authority than did PM's with smaller projects.

c. Size of a company had little bearing on the amount of authority perceived by a project manager within it. Smaller companies, however, tended to give PM's more freedom in making technical changes.

d. The more vertically developed a project organization, the more authority a project manager perceived himself as having in making cost changes and preparing the budget.

e. Project managers in smaller companies perceived themselves as having greater authority in selecting subcontractors than did those in larger companies.

C. DISCUSSION OF RESULTS

1. The Importance of Dollar Value

The number of significant relationships shared by the dollar value of a project with other variables indicated the "power of the purse" in establishing an organization. It was, for example, the only structural variable closely linked with both staff selection authority and the degree to which the project manager was removed from corporate or group management (layering). Its correlation with factors such as the size of a company (both in annual sales and number of employees), product complexity, and government involvement were clear when the range of the sample was considered. The value of contracts involving the manufacture of the A-7E aircraft or PHOENIX missile system, for example, represented more money than several of the sampled companies have handled in a decade. These expensive, complex, longtime programs often represent the major effort of large companies, and could not likely be effectively managed by the smaller ones.

The effects of dollar value on the establishment of an organization were also obvious. Most managers of costly projects had previous experience managing smaller ones. Thus, not only were the managers of important projects more likely to be found near the top of an organization chart, but they were also senior in terms of prior experience.

The inverse correlation between layering and all the authority variables indicates that higher ranking managers

have gained a great deal of their superiors' confidence, perhaps by learning the way top managers think, and what kind of decisions are in the company's best interest.

The lack of significant correlation between dollar value and most of the authority variables is more difficult to explain. It correlated only with staff selection and contract negotiation, the two variables associated with the earliest phases of the project. This indicates that while a project manager is given considerable leeway in "launching" his project, that upper management wants more control over such areas as cost, schedule and technical changes.

2. Organizational Form

Organizational form was found to be significantly linked with company size (both in sales and employees), product complexity, and dollar value. These bonds appeared, despite two large, complex projects being organized in functional form. The two A-7 aircraft projects of Vought Aeronautics represent a majority of that company's business Being involved in its development are all their functional departments. It follows that project staffs cannot help but lose some identity in comparison with those of other companies.

Notably missing from the A-7 program managers' lists of problems were the personnel conflicts that so commonly appear in matrix structures. The extent to which program goals are synonymous with those of the company tends to create the image that Vought Aeronautics is something of a vertically organized "super-project" within LTV Aerospace Corporation.

In this respect, Vought may actually be more of a one-product vertical organization than the functional form it was labeled by the project managers.

Several respondents indicated that their projects tended to become more autonomous as they grew in importance to the company. Most firms, however, refrained from making common use of the pure project form. TRW Systems Group, for example, required approval of its General Manager before establishing a monolithic project requiring more than one divisions's resources. Cited most often for the reluctance to use this form was inefficiency to the company, caused by a disproportionate allocation of resources to a specific project.

3. Authority Relationships

Respondents were questioned on their authority in seven specific areas. We found that, in general, managers who perceived themselves as having a great deal of authority in one area were likely to have similar perceptions of their role in other areas.

However, there was a general lack of significant correlation between authority variables and most structural variables. The effects of layering and the staff selection authority common to high dollar value projects have been discussed previously. One other relationship noted was the tendency for managers in smaller companies to have more control over technical changes than is the case in larger firms. Examination of the questionnaires revealed that the amount of authority in most areas tended to vary from one firm

to another, rather than between projects. However, except for technical change, no particular pattern was evident. It was not feasible to rank-order firms in such a way that significant Kendall's correlations could be found.

4. The Role of Involvement

While the degree of government involvement in its contractors' projects is neither a structural variable nor an area of authority, it was closely linked to certain project characteristics. DOD was most likely to involve itself deeply in projects of high dollar value. Where a vast amount of money was invested it was deemed appropriate to provide a staff of government representatives to monitor the firm's progress. Such staffs took the forms of Naval Plant Representative Offices, Defense Contract Administration Services Offices, or Technical Representatives. In certain cases, the General Accounting Office maintained on-site supervision. Functions of such staffs included financial accounting, auditing, inspecting, testing, and providing technical assistance, as well as maintaining liaison between the firm and its customer.

Larger firms were observed as the most likely to have great degrees of government involvement, due largely to their link with costly and complex products. Moreover, it was economically feasible for a service to establish contract administration offices near companies with a large number of government contracts, whether or not a particular one is costly.

IV. PROBLEMS OF PROJECT MANAGEMENT

A. GENERAL

The typical problems of project organizations were mentioned earlier in the discussion of advantages and disadvantages of the principal organizational forms. In the process of collecting data for this study, project managers were asked to discuss the three problems that created the greatest obstacles to normal execution of their tasks. Although more than 50 distinct problems were reported, they have been combined into nine areas to avoid redundancy in analysis. Table 1 lists the problem areas and the percentage of respondents that mentioned them.

Problem Area	% of Responses
Personnel	44
Government control	38
Coordination of many departments	38
Money	30
Internal organization	19
Communication	19
Changes	15
Schedule	13
Miscellaneous	33

TABLE 1

B. PERSONNEL

One aspect of this problem was typically and succinctly discussed by a manager, citing his principal problem as "getting competent manpower assigned promptly when needed." Thus, two problems were found in one: the need for qualified personnel, provided in a timely manner. In addition, several

managers reported difficulty in obtaining motivated people or in staffing their offices with employees who understand the relationship between project and functional organizations. Motivation was found to decline as a project neared completion. Personnel were reluctant to leave the security of one job for the uncertainty of another.

The personnel referred to were involved in two distinct conflicts. The first was between project and functional managers, with their natural differences in goals and methodology. The second was caused by competition with other projects for the most capable and motivated workers.

C. GOVERNMENT CONTROL

Complaints of government control were often general, simply citing "excessive red tape" or "bad customer attitude" in several responses. However, one manager described the government as a "many-faceted customer," citing the difficulty of meeting the varied requirements of the General Accounting Office, Congress, Office of the Secretary of Defense, and various branches of the Navy.

Ignorance in technical matters and contractor capabilities was mentioned, as well as indecision, unnecessary interference, excessive paperwork requirements, slow reactions in making changes, and complex contracting methods.

D. COORDINATION OF MANY DEPARTMENTS

Lack of authority over functional managers and workers, particularly in manufacturing, was mentioned most often as a major obstacle in the area of coordination. Managers also expressed difficulty in obtaining early definition of interfaces, clear understanding of priorities, and dependable decision-making channels. One mentioned that planning often occurred without awareness on the planners' part of all departments' capabilities and constraints.

E. MONEY

Money problems usually included lack or uncertainty of funds. Reasons given were numerous, but can be generalized to include:

1. Tight budgets resulting from competitive bidding and inaccurate cost estimates. One manager suggested that savings would result if "enough money were made available at the beginning of a project to do the job right the first time."

2. Delay in cost/schedule reporting systems. Project managers from seven of the 12 firms mentioned lack of financial visibility.

3. No control over manufacturing overhead costs.

F. INTERNAL ORGANIZATION

Many of the problems associated with the government, such as red tape and slow reaction, spilled into the firms' internal organizations. Although slower (as a group) to criticize themselves, several managers refused to pass the buck beyond their own organization. Several mentioned lack

of planning, inability to survive the "system," and poor task orientation as sources of their problems. One described the key to success as "understanding the system and surviving in spite of it." Problems in this area often overlapped communications difficulties.

G. COMMUNICATION

Inadequate reporting systems, failure to get the word, and geographic dispersion were the only complaints assigned to this category that appeared more than once. However, this overlapped into many other areas, such as the cost/schedule reporting delays mentioned earlier. It was closely related to the difficulties involved in the area of coordination. Furthermore, it could accurately be labeled as the underlying cause for many problems associated with personnel, schedules, and internal organization.

H. CHANGES

While only listed among their three most difficult problems by 11 managers, changes seemed to plague most of the people interviewed. Design problems were often the cause of changes that also affected cost and schedule. Numerous reviews, both in-house and by the government, resulted in costly and time-consuming changes. Particularly annoying were the periods of waiting that result from slow reactions by both the government and company to recommendations for changes. The opinion of most project managers was to minimize changes of all kinds. They felt that most changes

only compounded existing problems relating to schedule, money, and communication.

I. SCHEDULE

Problems falling into this category were also closely related to many other areas. Schedules were termed "unrealistic" and "unreasonable," usually the result of poor planning and lack of communication. Highly complex projects were hampered by long lead times, and lack of one part occassionally brought an entire program to a standstill. A project manager stressed the need for not letting decisions slide: "You lose schedule one hour at a time, not three months at a time. Decisions regarding spending, personnel changes, and technical performance have to be made."

J. MISCELLANEOUS

A number of significant problems failed to fit into any of the previous categories. Among the more commonly listed were:

1. Component quality--achieving technical excellence despite rigid cost and schedule constraints.

2. Snowball effects of problem projects--additional inefficiencies that usually resulted from excessive attention.

3. Being surrounded by projects of another service--for example, managing an Air Force project in a company which did all other business with the Navy.

V. CONCLUSIONS

Project managers with broad authority in one area are likely to have similar perceptions of their authority in all other areas. Those with the greatest degree of authority are most likely to be managers of high dollar value projects, and ranked high in their companies' organizations.

A structural variable which was significantly related to all areas of perceived authority was layering. Those managers closest to the top of a corporation's organization chart had been promoted to that position by gaining both the confidence of their superiors and the required visibility of company goals. These factors enabled them to make more project decisions than lower ranking project managers.

The most common bonds shared by the project managers were their problems. Technical excellence was required of all their products, regardless of the dollar value of the project or the organizational form employed, and despite rigid cost, schedule, and personnel limitations.

The failure of a project's dollar value to link significantly with most authority variables raises a question which merits further investigation. Why does dollar value have a strong correlation with both staff selection and contracting authority and very little with project change authority? The author suggests that perhaps upper management becomes more, rather than less, involved in the decision process of

costly projects, once the stages of staff selection and contract negotiations are completed. It is recommended that once corporations have assigned the qualified managers to the most important projects, they should then delegate to them the authority to make project decisions, within rather wide boundary constraints. This will help reduce the costly time lag encountered in referring decisions to a higher level.

The author recommends that future research effort be directed toward the explanation of relationships between dollar value and the areas of perceived authority. Efficiency of operations may improve by making the authority delegated to a manager commensurate with the importance of his project.

APPENDIX A

SAMPLE QUESTIONNAIRE

Your time and effort in answering this questionnaire are greatly appreciated. Questions about projects refer to your present billet or most recent project experience. Inapplicable questions should be left unanswered. Please feel free to comment on any questions. An extra page is provided for any additional comments you care to make concerning project management in either the military services or defense industries.

Name _____

Position _____

PART A: Education and Experience

1. How many years of formal education have you completed? /__/__/

2. What degrees have you obtained? _____

3. In what fields? _____

4. In what general field has been the major emphasis of your education? (Enter appropriate number in space provided.)

a. As an undergraduate student? /__/

(1) Arts
(2) Social Science
(3) Management/Business Administration
(4) Science
(5) Engineering
(6) Other (specify) _____

b. As a graduate student? /__/

(1) Arts
(2) Social Science
(3) Management/Business Administration
(4) Science
(5) Engineering
(6) Other (specify) _____

5. Which of the following describe your previous experience in project management? Check as many as apply.

Informal courses of instruction ___
Formal courses of instruction ___
Work in functional organization ___
Work on previous projects ___
Managed previous projects ___
None ___

6. How many years of experience do you have in the field of project management? /__/__/

7. How many years have you been employed by your present firm? /__/__/

8. Other than normal promotions, how many times have you changed positions in technical or project organizations? /__/__/

PART B: Product Area

1. For what end-product is your project organization directly responsible? (aircraft, missile, radar, etc.)

_____

2. At what phase of the system life cycle is your current project/product?

a. Research/exploratory development ___
b. Advance design ___
c. Engineering design/development ___
d. Test and evaluation ___
e. Pilot production ___
f. Full-scale production ___

3. What is the approximate dollar value of contracts pertaining to this project? $_____

PART C: Project Office Organization

1. What type organization best describes your project office organization?*

a. Functional ___
b. Pure project (vertical) ___
c. Matrix ___
d. Other (specify) ___
e. See my organization chart ___

*Please send a copy of a published organization chart, if available.

2. How many people work solely within the project office organization? /___/___/

3. Of these, how many report directly to the project manager (rather than to a deputy, for example)? /___/___/

4. How many people are available fron functional departments outside the project office for assistance to the project manager? /___/___/

5. Of these, how many are involved entirely in your project? /_____/

6. How many levels exist in the structural organization of the project office, from project manager to the lowest level? /_____/

PART D: Project Manager's Role

1. How much authority do you have in selecting the project office staff?

a. None ___
b. A little ___
c. A lot ___
d. Total ___

2. How much authority do you have in negotiaging contracts?

a. None ___
b. A little ___
c. A lot ___
d. Total ___

3. How much authority do you have in selection of subcontractors?

a. None ___
b. A little ___
c. A lot ___
d. Total ___

4. To what degree is there involvement on the part of the government with regard to your project?

a. Very little ___
b. Occasional phone calls/letters/telegrams ___
c. Occasional visits ___
d. Routine periodic inspections ___
e. Constant by on-site office ___

5. How much responsibility do you have in preparation of your project's budget?

a. None ___
b. A little ___
c. A lot ___
d. Total ___

Use the following five choices in answering questions 6, 7, and 8:

a. All executed by corporate/group management
b. Most executed by corporate/group management
c. Recommended by project manager, approved by corporate/group management
d. Most executed by project office
e. All executed by project office

6. Which best describes your control over technical changes? __

7. Which best describes your control over schedule changes? __

8. Which best describes your control over cost changes? __

PART E: Problems

What are your three most difficult and obstructive problems in completing the job in the way you feel it should be done?

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

Please return to:

Lieutenant Carl P. McCullough, USN
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Monterey, California 93940

In partial fulfillment of the requirements for the degree of Master of Science.
Curriculum: Systems Acquisition Management
Advisor: Professor M.B. Kline

PART F: Additional Comments (optional)

APPENDIX B

FIRMS SAMPLED

FMC Corporation, Ordnance Division--San Jose, California

Ford Motor Company, Philco-Ford Corporation, Western Development Laboratory--Palo Alto, California

General Dynamics Corporation, Electro Dynamic Division--Pomona, California

General Telephone and Electronics Corporation, GTE Sylvania Incorporated, Western Division--Mountain View, California

Grumman Corporation, Grumman Aerospace Corporation--Bethpage, New York

Hughes Aircraft Company, Aerospace Group--Culver City California

Hughes Aircraft Company, Ground Systems Group--Fullerton California

LTV Corporation, LTV Aerospace Corporation, Vought Aeronautics--Dallas Texas

Lockheed Aircraft Corporation, Lockheed Missiles and Space Company--Sunnyvale, California

Singer Company, Singer Librascope, Aerospace and Marine Systems Group--Glendale, California

Teledyne, Incorporated; Ryan Aeronautical--San Diego, California

TRW, Incorporated; Systems Group--Redondo Beach, California

APPENDIX C

Matrix of "p" Values of Correlation Coefficients

	Number of Employees	Product Complexity	Layering	Dollar Value of Project	Organizational Form	Government Involvement	Staff Selection	Contracting	Subcontractor Selection	Budget Preparation	Technical Change Control	Schedule Change Control	Cost Change Control
Structural Variables: Annual Sales	.001	.005	-.089	.001	.003	.160	.149	.047	-.017	-.385	-.001	-.328	.351
Number of Employees		.002	-.034	.001	.007	.088	.201	.116	-.015	-.211	-.001	-.117	-.269
Product Complexity			-.239	.001	.003	.005	.042	-.488	-.195	-.484	.154	.316	.305
Layering				-.008	-.312	-.201	-.001	-.001	-.001	-.001	-.019	-.001	-.002
Dollar Value of Project					.003	.001	.005	.023	-.187	-.252	.396	.261	.112
Organizational Form						.087	.049	.131	-.234	.034	.131	.423	.010
Government Involvement							.031	.117	.217	-.164	-.027	.121	.196
Perceived Authority: Staff Selection								.001	.001	.001	.028	.003	.040
Contracting									.001	.001	.018	.001	.001
Subcontractor Selection										.001	.013	.001	.143
Budget Preparation											.001	.001	.001
Technical Change Control												.001	.001
Schedule Change Control													.001

Significance of relations:

Among structural variables alone

Between structural variables and areas of perceived authority

Among areas of perceived authority alone

Government Involvement was conceptually distinct from the structural and perceptual variable clusters.

APPENDIX D

N \ p	.050	.010	.001
87	.119	.169	.224
86	.120	.171	.227
70	.130	.184	.244
50	.160	.226	.300

Values of Kendall's rank-order correlation coefficient corresponding to selected sample sizes (N) and significance levels (p).

COMPUTER OUTPUT

KENDALL'S CORRELATION COEFFICIENTS

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
ANNSALES	0.8796	ANNSALES	0.1510	ANNSALES	0.4113
WITH	N(87)	WITH	N(86)	WITH	N(49)
EMPLOYED	SIG .001	CPLEXITY	SIG .020	LVLSUP	SIG .001
ANNSALES	-0.0379	ANNSALES	-0.3298	ANNSALES	0.0910
WITH	N(87)	WITH	N(87)	WITH	N(87)
CONTRACT	SIG .302	SUBCONT	SIG .001	INVOLVE	SIG .106
ANNSALES	-0.1625	EMPLOYED	0.1726	EMPLOYED	0.3050
WITH	N(86)	WITH	N(86)	WITH	N(49)
COSTCHG	SIG .013	CPLEXITY	SIG .009	LVLSUP	SIG .001
EMPLOYED	-0.0629	EMPLOYED	-0.3294	EMPLOYED	0.1122
WITH	N(87)	WITH	N(87)	WITH	N(87)
CONTRACT	SIG .194	SUBCONT	SIG .001	INVOLVE	SIG .062
EMPLOYED	-0.2179	CPLEXITY	-0.0701	CPLEXITY	0.44 3
WITH	N(86)	WITH	N(49)	WITH	N(8)
COSTCHG	SIG .001	LVLSUP	SIG .239	DOLVAL	SIG .0 1
CPLEXITY	-0.0631	CPLEXITY	0.1876	CPLEXITY	-0.00 0
WITH	N(86)	WITH	N(86)	WITH	N(8)
SUBCONT	SIG .195	INVOLVE	SIG .005	BUDGET	SIG .484
LVLSUP	-0.2441	LVLSUP	-0.0483	LVLSUP	-0.3418
WITH	N(47)	WITH	N(49)	WITH	N(49)
DOLVAL	SIG .008	ORGTYPE	SIG .312	STAFFSEL	SIG .001
LVLSUP	-0.3265	LVLSUP	-0.2040	LVLSUP	-0.3614
WITH	N(49)	WITH	N(49)	WITH	N(49)
BUDGET	SIG .001	TECHCHG	SIG .019	SKEDCHG	SIG .001

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
ANNSALES	0.1879	ANNSALES	0.1565	ANNSALES	-0.1132
WITH	N(81)	WITH	N(87)	WITH	N(87)
DOLVAL	SIG .007	ORGTYPE	SIG .016	STAFFSEL	SIG .060
ANNSALES	-0.2068	ANNSALES	-0.3913	ANNSALES	-0.2277
WITH	N(87)	WITH	N(86)	WITH	N(86)
BUDGET	SIG .002	TECHCHG	SIG .001	SKEDCHG	SIG .001
EMPLOYED	0.2032	EMPLOYED	0.1412	EMPLOYED	-0.1215
WITH	N(81)	WITH	N(87)	WITH	N(87)
DOLVAL	SIG .004	ORGTYPE	SIG .026	STAFFSEL	SIG .048
EMPLOYED	-0.2331	EMPLOYED	-0.3810	EMPLOYED	-0.2669
WITH	N(87)	WITH	N(86)	WITH	N(86)
BUDGET	SIG .001	TECHCHG	SIG .001	SKEDCHG	SIG .001
CPLEXITY	0.2040	CPLEXITY	0.1270	CPLEXITY	-0.0022
WITH	N(86)	WITH	N(86)	WITH	N(86)
ORGTYPE	SIG .003	STAFFSEL	SIG .042	CONTRACT	SIG .488
CPLEXITY	0.0754	CPLEXITY	0.0353	CPLEXITY	0.0376
WITH	N(85)	WITH	N(85)	WITH	N(85)
TECHCHG	SIG .154	SKEDCHG	SIG .316	COSTCHG	SIG .305
LVLSUP	-0.4211	LVLSUP	-0.4941	LVLSUP	-0.0827
WITH	N(49)	WITH	N(49)	WITH	N(49)
CONTRACT	SIG .001	SUBCONT	SIG .001	INVOLVE	SIG .201
LVLSUP	-0.2834	DOLVAL	0.2095	DOLVAL	0.1971
WITH	N(49)	WITH	N(81)	WITH	N(81)
COSTCHG	SIG .002	ORGTYPE	SIG .003	STAFFSEL	SIG .005

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
DOLVAL	0.1506	DOLVAL	-0.0673	DOLVAL	0.2624
WITH	N(81)	WITH	N(81)	WITH	N(81)
CONTRACT	SIG .023	SUBCONT	SIG .187	INVOLVE	SIG .001
DOLVAL	0.0926	ORGTYPE	0.1208	ORGTYPE	0.0818
WITH	N(80)	WITH	N(87)	WITH	N(87)
COSTCHG	SIG .112	STAFFSEL	SIG .049	CONTRACT	SIG .131
ORGTYPE	0.0822	ORGTYPE	0.0142	ORGTYPE	0.1700
WITH	N(86)	WITH	N(86)	WITH	N(86)
TECHCHG	SIG .131	SKEDCHG	SIG .423	COSTCHG	SIG .010
STAFFSEL	0.2518	STAFFSEL	0.1398	STAFFSEL	0.2049
WITH	N(87)	WITH	N(86)	WITH	N(86)
BUDGET	SIG .001	TECHCHG	SIG .028	SKEDCHG	SIG .003
CONTRACT	0.3326	CONTRACT	0.1538	CONTRACT	0.3711
WITH	N(87)	WITH	N(86)	WITH	N(86)
BUDGET	SIG .001	TECHCHG	SIG .018	SKEDCHG	SIG .0
SUBCONT	0.1637	SUBCONT	0.2853	SUBCONT	0.07
WITH	N(86)	WITH	N(86)	WITH	N(8)
TECHCHG	SIG .013	SKEDCHG	SIG .001	COSTCHG	SIG .1 3
INVOLVE	0.0629	BUDGET	0.3193	BUDGET	0.3220
WITH	N(86)	WITH	N(86)	WITH	N(86)
COSTCHG	SIG .196	TECHCHG	SIG .001	SKEDCHG	SIG .001
SKEDCHG	0.5092				
WITH	N(86)				
COSTCHG	SIG .001				

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
DOLVAL	-0.0506	DOLVAL	0.0200	DOLVAL	0.0489
WITH	N(81)	WITH	N(80)	WITH	N(80)
BUDGET	SIG .252	TECHCHG	SIG .396	SKEDCHG	SIG .261
ORGTYPE	-0.0529	ORGTYPE	0.0992	ORGTYPE	0.1334
WITH	N(87)	WITH	N(87)	WITH	N(87)
SUBCONT	SIG .234	INVOLVE	SIG .087	BUDGET	SIG .034
STAFFSEL	0.5078	STAFFSEL	0.2495	STAFFSEL	0.1358
WITH	N(87)	WITH	N(87)	WITH	N(87)
CONTRACT	SIG .001	SUBCONT	SIG .001	INVOLVE	SIG .031
STAFFSEL	0.1287	CONTRACT	0.2531	CONTRACT	0.0868
WITH	N(86)	WITH	N(87)	WITH	N(87)
COSTCHG	SIG .040	SUBCONT	SIG .001	INVOLVE	SIG .117
CONTRACT	0.3052	SUBCONT	0.0569	SUBCONT	0.28[illegible]
WITH	N(86)	WITH	N(87)	WITH	N([illegible]
COSTCHG	SIG .001	INVOLVE	SIG .217	BUDGET	SIG .0[illegible]1
INVOLVE	-0.0713	INVOLVE	-0.1415	INVOLVE	0.0859
WITH	N(87)	WITH	N(86)	WITH	N(86)
BUDGET	SIG .164	TECHCHG	SIG .027	SKEDCHG	SIG .121
BUDGET	0.2847	TECHCHG	0.5245	TECHCHG	0.3591
WITH	N(86)	WITH	N(86)	WITH	N(86)
COSTCHG	SIG .001	SKEDCHG	SIG .001	COSTCHG	SIG .001

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BSTRACT

In recent years, companies involved in contracting with the Department of Defense have organized project offices to manage the development and production of defense systems. The organizational structures and authority relations of these offices are unlike those common to other activities. This study sought to identify and explain the relationships that exist between structural and authority variables of project management systems. Data was collected by structured survey questionnaires directed to project managers and related functional managers. A correlational analysis was employed to measure the strength of relationships between attitudes and structural variables.

Although the dollar value of a project proved to be an important structural variable, the most reliable predictor of a manager's perceived authority was the number of layers between him and the top level of corporate management.

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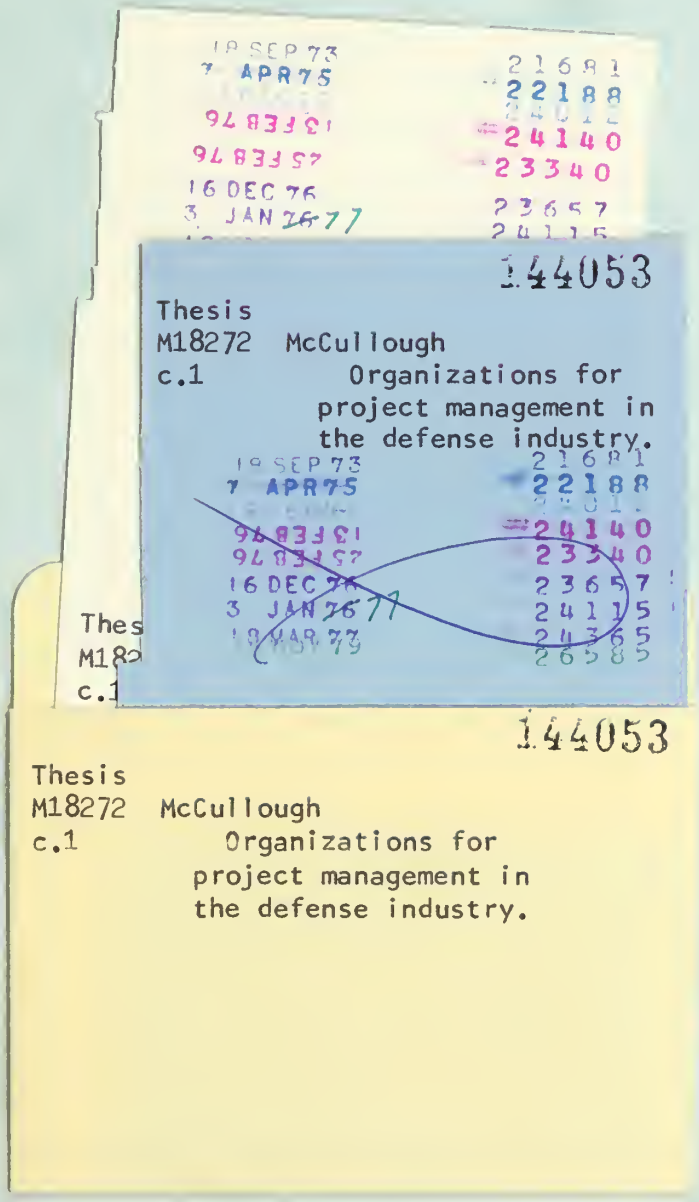
Matrix Organization						
Vertical Organization						
Functional Organization						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